Femtosecond Laser Ablation of a Solid Tin Target

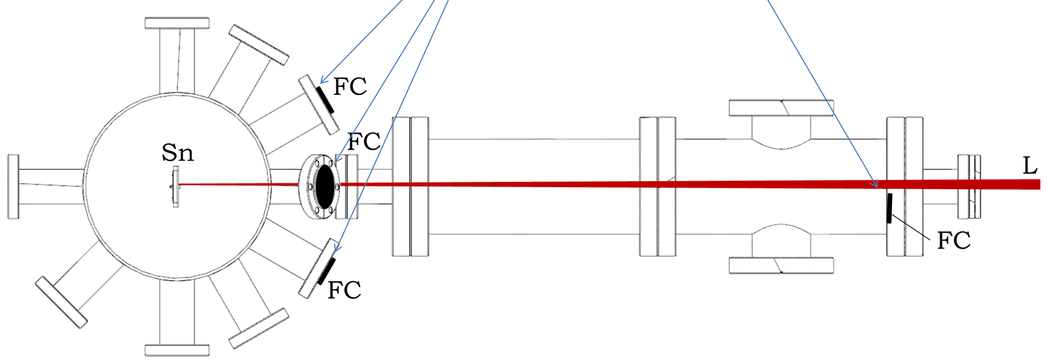
M.J. Deuzeman*,†, E. Leerssen*, A. Stodolna*, N. Spook*,‡, S. Witte*,§, P.C.M. Planken*,‡, K.S.E. Eikema*,§, W. Ubachs*,§, R. Hoekstra*,†, O.O. Versolato*

* *Advanced Research Center for Nanolithography (ARCNL), Science Park 110, 1098 XG Amsterdam, The Netherlands*
† *Zernike Institute for Advanced Materials, University of Groningen, Nijenborgh 4, 9747 AG Groningen, The Netherlands*
§ *Department of Physics and Astronomy, Vrije Universiteit, De Boelelaan 1081, 1081 HV Amsterdam, The Netherlands*
‡ *Van der Waals-Zeeman Instituut, University of Amsterdam, Science Park 904, 1098 XH, Amsterdam, The Netherlands*

Synopsis The results of a study on femtosecond laser ablation of a solid tin target are presented. We show the ion yield and energy distributions, the angular distribution, and the ablation depth for the pulse length and pulse energy.

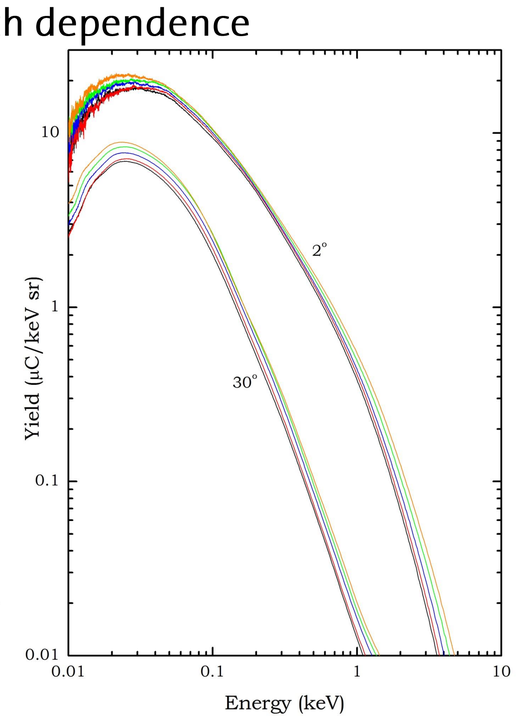
Experimental Setup

- Laser: 800 nm pulses at effective rate of 5 Hz
- Target: planar solid Sn target
- A Faraday Cup (FC) at 2° (at 70 cm) and three FCs at 30 degrees (at 24 and 26 cm) to measure ion distributions.

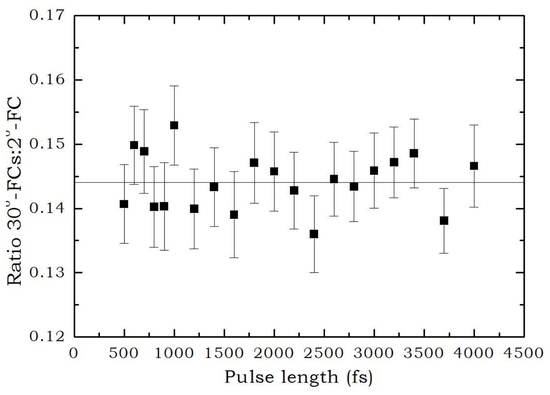


Pulse length dependence

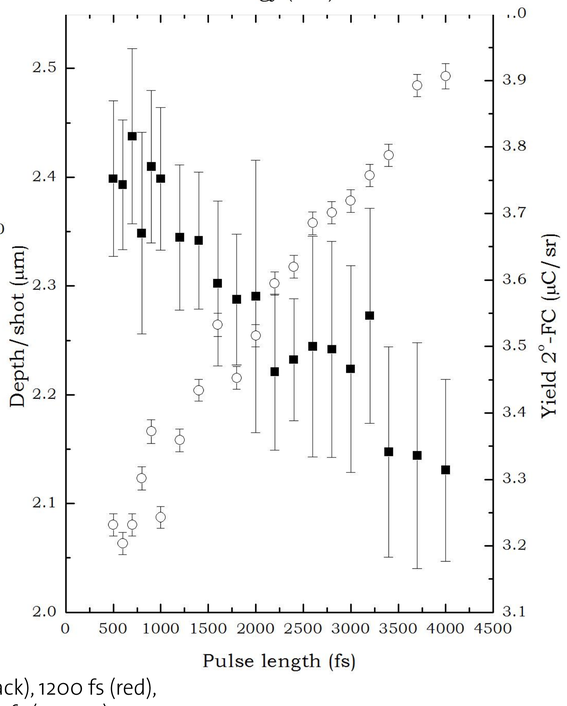
More ions for all energies at longer pulse lengths, especially high-energy ions



Constant ratio yields: angular distribution is not dependent on pulse length.



Yield increases with 30% while ablation depth decreases with 10% for this range.

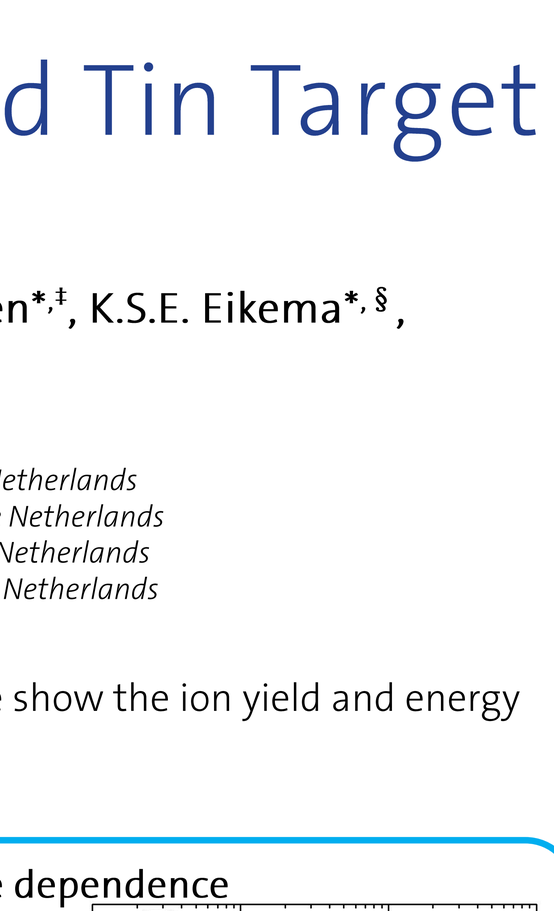


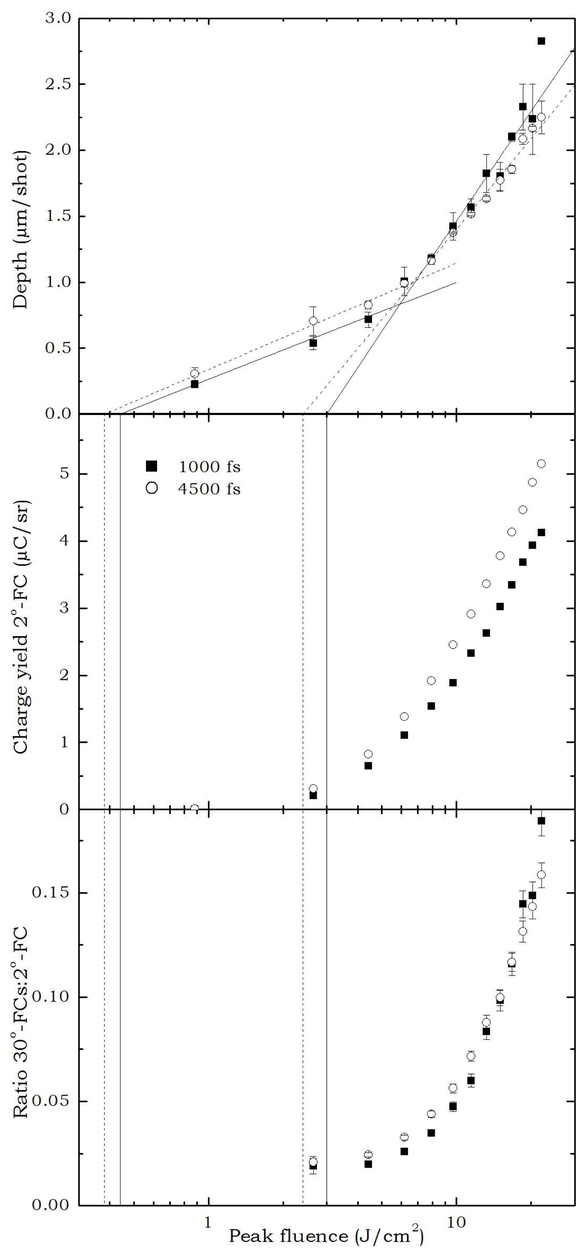
Five pulse lengths are shown: 500 fs (black), 1200 fs (red), 2000 fs (blue), 3000 fs (green) and 4000 fs (orange).

Peak fluence dependence

Majority of ions have low energy (up to 100 eV), more high-energy ions for higher fluences.

Additional high-energy peak is visible, but indistinguishable at higher fluences and 2°.

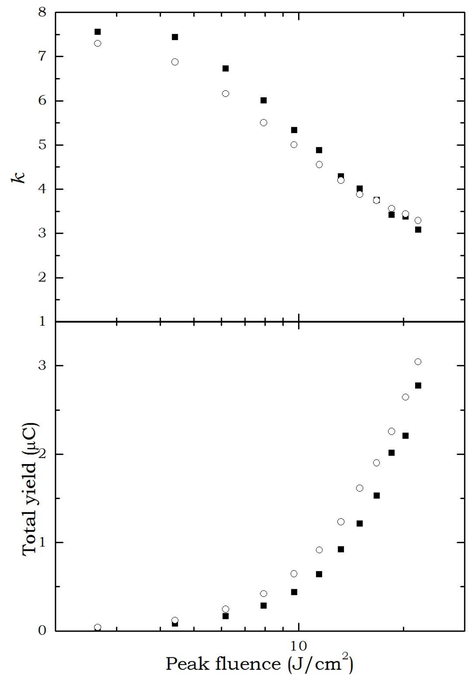




Ablation depth has two-region logarithmic dependence with fairly constant ablation threshold:

$$\delta = B \ln\left(\frac{F}{F_{th}}\right)$$

-Yield increases gradually.with more ions at 4000 fs
-The angular distribution is rapidly broadening;



Plasma can be described by:

$$\frac{Y(\phi)}{Y(0)} = \frac{[1+\tan^2\phi]^{3/2}}{[1+k^2\tan^2\phi]^{3/2}}$$

Conclusions

- The bulk of the ions have low energy, below 100 eV, although the fraction of high-energy ions increases for higher fluences
- The ablation depth has a two-region logarithmic dependence on the fluence. The yield increases gradually and the distribution broadens.
- The ion yield increases for increasing pulse length, while the ablation depth decreases slightly. The angular distribution stays the same.

ARCNL
ADVANCED RESEARCH CENTER FOR NANOLITHOGRAPHY

ARCNL is a public-private partnership between FOM, UvA, VU and ASML

ASML · Gemeente Amsterdam · Provincie Noord-Holland · VU University Amsterdam · University of Amsterdam · university of groningen · NWO · FOM